GRIZZLY BEAR HABITAT USE AND DISTURBANCE STUDIES:

SOUTH FORK OF THE FLATHEAD RIVER.

PROGRESS REPORT FOR 1991

PLEASE RETURN

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INTRODUCTION

Intensive habitat research on grizzly bears in the lower 48 States began with the work of the Craigheads in the Yellowstone Area between 1959 and 1970. After the grizzly bear was listed as a threatened species in 1975, habitat research was expanded to other areas still inhabited by the grizzly bear. Since 1975, most efforts on habitat research have dealt with basic habitat use and food habits.

In the Northern Continental Divide Ecosystem (NCDE), habitat preference studies have been conducted in the Mission Mountains (Servheen and Lee 1979; Servheen 1983), the Rocky Mountain East Front (Schallenberger and Jonkel 1979; Aune and Kasworm 1989), Glacier National Park (Martinka 1976), and the South Fork of the Flathead River (Mace and Jonkel 1980, Zager et al. 1983). Extensive research was also conducted by McLellan (1986) in Southeastern British Columbia adjacent to the Montana border.

Mapping of grizzly bear habitat within the NCDE has been attempted using several different methods. Craighead et al. (1986) used satellite imagery to map habitat in the Scapegoat Wilderness as did Butterfield and Key (1986) for the Two Medicine area of Glacier National Park. The U.S. Forest Service used aerial photos and hand mapping, to map habitat components following Madel (1982) and then switched to LANDSAT satellite imagery. Mace (1986) mapped grizzly bear habitat in a portion of the Bob Marshall Wilderness using vegetation types. Hadden et al. (1987) mapped habitat by

community type in the South Fork of the Flathead River.

Several recent studies have investigated the potential effects of human activities associated with roads, timber harvest, mineral exploration, and development on grizzly bear use of habitat. Mattson et al. (1986) studied the effects of roads and developments within Yellowstone National Park. Kasworm and Manley (1990) documented road and trail influences in the Cabinet Mountains of western Montana. Within the NCDE Mclellan and Shackleton (1988) investigated the effects of roads and resource extraction on grizzly bear behavior and habitat use in Southeastern British Columbia and Aune and Kasworm (1989) analyzed grizzly bear locations in relationship to roads and seismic activity along the East Front.

Researchers have examined grizzly bear locations with regard to distance from roads, but information is lacking regarding grizzly bears and specific road densities. While distance to road measurements are informative, land managers are using road densities to manage grizzly bear habitat. For research findings to be compatible with management recommendations, we developed a method of combining road density and grizzly bear use.

In this annual report, we present preliminary findings on grizzly bear responses to roads, and detail our methods for evaluating grizzly bear habitat with satellite imagery. Information on other habitat objectives will be generated later.

OBJECTIVES

1. To collect grizzly bear information using radio telemetry.
2. To quantify and compare grizzly bear habitat selection in multiple use and wilderness/roadless areas.
3. To develop habitat maps using LANDSAT Thematic Mapper (TM) satellite imagery.
4. To determine the effects of roads on the use of habitat by grizzly bears and how road traffic influences habitat effectiveness.

    a.) quantify habitat values related to road density zones.

    b.) document short term response to road closures.

STUDY AREA

The study area was approximately 1456 km^2 in size and was within the South Fork of the Flathead River Drainage in Northwestern Montana (Figure 1). The study area, situated in the Swan Mountain Range, was bounded by the Flathead River on the north, Hungry Horse Reservoir to the east, The Bob Marshall Wilderness to the south, and the Swan and Flathead valleys to the west. The study area was mostly under public ownership within the boundaries of the Flathead National Forest and administered by Hungry Horse, Spotted Bear, and Swan Lake Districts.
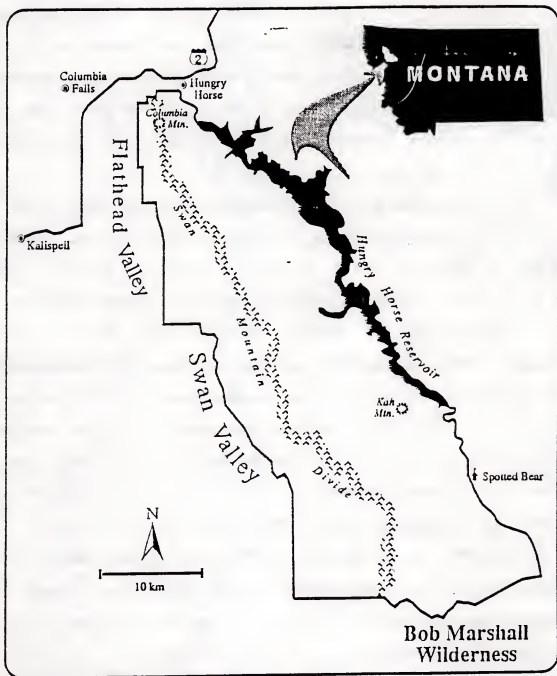
Figure 1. Study area.

Management emphasis by the U.S. Forest Service was semiprimitive motorized and non-motorized recreation in the higher elevations, timber production at lower elevations, and big game winter range on portions of Kah Mountain and along the Swan and Flathead valleys. Every major drainage contained an open or closed road along the drainage bottom. Roads closed to motorized vehicles were either seasonal or permanent closures.

Recreational activities observed in the area included big game hunting, fishing, hiking, camping, berry picking, wood cutting, snowmobiling, and riding all terrain vehicles (ATV's).

The topography is mountainous with elevations of 915 m. along the Flathead Valley to 2316 m. along the Swan Range divide. Pacific maritime weather patterns predominated resulting in an average annual precipitation in excess of 250 cm, the majority of which fell in the form of snow. Geologic data have been described by Johns (1970), and land type inventories have been completed by the U.S. Forest Service (USDA 1979). Historical information was found in Delk (1973) and Mitchell (1973).

Due to the different elevations, slope, aspect, moisture regimes, soils, the effects of wildfire, and timber harvest, vegetation communities are very diverse. Hadden et al. (1987) described and mapped 51 community types within the study area. These community types ranged from mesic-xeric grasslands on steep southerly aspects to very moist Sitka alder/devil's club (<u>Alnus sinuata</u>/<u>Oplopanax</u> <u>horridum</u>) shrubfields in riparian zones to the high elevation Whitebark pine/whortleberry (<u>Pinus</u>

albicaulis/<u>Vaccinium scoparium</u>) type (Hadden et al. 1987).

METHODS

Snaring procedures

Grizzly bears were trapped using a systematic snaring grid (Mace and Manley 1990). During the spring of 1988 and 1989, 64 capture sites were within the study area. During the spring of 1990, 37 capture sites were located within the study area, the difference due to severe road damage and logistical constraints. During 1991 trapping efforts were aimed at Bunker Creek to attempt to increase the sample of "wilderness bears". Additional trapping was done throughout the core of the study area to recapture bears that had lost or were due to lose radio collars. Captured bears were immobilized and marked as described in Mace and Manley (1990).

Telemetry

Captured grizzly bears of at least 1.5 years of age were fitted with neck-mounted radio collars equipped with real-time activity sensors (Telonics, Mesa, AZ). Cotton spacers (Blue Star Tepee, Missoula, MT) were attached to the belting of each collar. These spacers would eventually decay and the collar would fall off (Hellgren et al. 1988). In the fall of 1987, four Argos System satellite tracking transmitters (Telonics, Mesa, AZ) were placed on 4 grizzly bears for testing purposes. In 1989 these 4 collars were

replaced with standard collars as the bears were recaptured.

Radio-instrumented grizzly bears were monitored weekly from fixed-wing aircraft (Cessna 180 and 182) during 1988 and 1989. In 1990 and 1991 bears were located twice a week from fixed-wing aircraft. A color Polaroid photograph was taken of each aerial location. After the photograph developed, the location was marked on the photograph while the airplane was still over the location. Information such as drainage, time, activity, visual, other bears, cover type, special feature, and canopy coverage were recorded on the bottom of the photograph.

After the flight, locations from the photographs were transferred to 1:24,000 black and white orthophoto quads. Slope, elevation, aspect, and Universal Trans Mercator (UTM) coordinates were recorded to tenths of meters for each location. All grizzly bear locations that were within UTM zone 11 were converted to UTM zone 12. The data were entered into a computer database created and managed using Foxbase+ (Fox Software, 1988).

Ground locations were obtained as possible using triangulation. Past efforts at ground tracking had revealed significant problems and error in mountainous terrain. Error polygons were computed and plotted for each ground location, and the UTM coordinates were recorded for the center of each polygon.

All grizzly bear locations were grouped into eight different classes:

1. Aerial locations that were specific and had the least observer bias (the best locations for habitat analysis).

2. Ground telemetry locations that were specific but locations biased toward observer access (useful for some habitat analysis).

3. Capture or baited camera site locations that were specific but bears were attracted to the site by bait (not used for habitat analysis).

4. Aerial locations that were general (not used for habitat analysis).

5. Ground locations that were general (not used for habitat analysis).

6. Aerial or ground locations that were very general (not used for habitat analysis).

7. Location were a bear was killed (not used for habitat analysis).

8. Camera locations where bears were photographed along roads (no attractants were involved).

For this report only the class 1 locations were used.

Habitat selection

Macro selection:

Habitat characteristics of grizzly bear use sites were assessed using a hierarchial system (Gauch 1982). Each specific aerial radio location was assigned to one of 10 cover types and special features (Table 1). Designations were initially made from the air and later ground checked for verification. Cover type and special feature classifications from specific ground triangulations

were assigned during ground reconnaissance and from orthophoto interpretation. The error polygon associated with each specific ground location was field-searched for evidence of bear presence.

Table 1. Cover types and special features recorded for each grizzly bear location.

COVER TYPE	SPECIAL FEATURE
Coniferous forest (>40% canopy)	Snowchute (non-scoured)
Deciduous forest (>40% canopy)	Snowchute (scoured)
Alpine	Talus Scree
Tree wetland (>25% tree)	Slabrock
Shrub wetland (>25% shrub)	Cutting unit
Herbaceous wetland (>10% herb.)	Rock outcrop
Shrubland (>15% shrub,<40% tree)	Road
Grass/forbland (>10% herbaceous)	Creekbottom
Non-vegetated (<10% rooted veg.)	Montane
Unknown	Unknown

Cover type and special feature classes for that location were based on verified grizzly bear use sites. In cases where grizzly bear sign was not observed within an error polygon, each distinct cover type and special feature within the polygon were recorded. In

cases where specific locations were in deep snow or could not be verified the cover type and/or special feature were classified as unknown.

Microsite selection:

Microsite habitat use studies were conducted at representative bear use sites. A modification of the U.S. Forest Service "cover microplot" method (USDA 1988) was used to gather vegetative and site characteristics data at specific grizzly bear locations. Attempts were made to visit the locations as soon as the grizzly bear left the immediate vicinity. If more than a week passed before a location could be visited it would be removed from the 'visitation' list and replaced by a more recent location. An attempt was made to visit as many different types of habitats as possible.

At each site, a $1/10^{th}$ acre macroplot was established parallel to the slope contour. The macroplot was further divided into twenty 400 in^2 microplots. Five microplots were evenly spaced along 4 transects running parallel to the slope contour. Herbaceous, shrub, and non-vegetated ground cover were described within each of the 20 microplots.

Overstory coverage values within the macroplot were estimated for each tree species. Coverage values were derived for each of 5 age/size classes: seedling, sapling, pole, mature, and large mature. Each macroplot was classified as being either open (0-10% canopy coverage), open-timbered (10-40% canopy coverage), or

timbered (>40% canopy coverage). Macroplots were also classified as one of 8 structures: nonvegetated-moss, herbaceous-seedling, shrub-shrub seedling,sapling, pole-sapling, young-mature, old growth, and krumholtz. Cover value for grasses, herbs, and shrubs within each microplot were recorded using the following coverage classes: 0.1-1%, 1-5%, 5-15%, 15-25%, 25-35%, 35-45%, 45-55%, 55-65%, 65-75%, 75-85%, 85-95%, 95-100%. Total coverage values for herbaceous, low shrub (<6 in.), mid-shrub (6 in. to 4.5 ft.), and tall shrub (>4.5 ft.) were recorded for each microplot. Unidentified plants were collected for species verification, and botanical nomenclature followed Hitchcock and Cronquist (1973).

Elevation, aspect, and slope were recorded for the center of each macroplot. A relative measure of soil moisture was also recorded: inundated, seasonally inundated, moist, dry, and xeric.

Evidence of grizzly bear foraging activity was recorded within each macroplot. The phenological stage of plant foods was also assessed using the following classification: <3/4 leaf development with no flowers, 3/4 to full leaf with no flowers flowering with leaves, seeds developed with leaves, fruits developed, senescent leaves, and vegetal development only. Plant food density was estimated within the macroplot by counting individual food plants or berries in five randomly selected microplots. Using this procedure, estimates of plant foods/acre were calculated.

Relationships between grizzly bears and roads

Traffic volumes:

In cooperation with the U.S. Forest Service, traffic counters were placed to monitor forest roads in and adjacent to the study area. Counters were read weekly by Forest Service personnel. Research personnel recorded the date, time, and number of trips each time a counter was crossed. This was done to determine the proportion of traffic volume due to research personnel.

Remote cameras:

Nineteen remote cameras (Aune et al., 1991) were placed on 6 different roads. Eight of the sites were on roads with unrestricted public access. Three sites were on seasonally restricted roads and the remaining 8 sites were on permanently closed roads. As part of our research we restricted our vehicle traffic at 2 of the permanently closed sites. Cameras were placed perpendicular to the roads and oriented toward the north as possible. These cameras were passive as baits and/or attractants were not used. We wanted to document when grizzly bears were using the roaded areas because there was concern that aerial flights may not be adequately sampling the grizzly bears use of those areas due to the bias of diurnal locations.

Road mapping and classification:

All roads within and adjacent to the study area were digitized from 1:24,000 orthophoto quads using the digitizing package in

EPPL7 (Minnesota State Planning Agency, 1990). New roads were added from topographic maps obtained from The Flathead National Forest. Roads were grouped into six classes:

Class 1. Primary road - main gravel or paved road that was maintained on an annual basis, and received the highest proportion of vehicular traffic.

Class 2. Secondary - gravel road off the primary road, usually maintained on a yearly basis, passable to all types of vehicles.

Class 3. Tertiary - gravel road off the primary or secondary roads that were not maintained but were passable with 2-wheel drive pickup trucks.

Class 4. Roads that were not maintained and were passable only with 4-wheel drive trucks or ATV's.

Class 5. Roads that were revegetated with shrubs and/or trees and were no longer passable with an ATV.

Class 6. Paved State and Federal highways.

Each road was further classified as permanently open, seasonally open, or permanently closed.

The digitized road file was rasterized to 30 meters in EPPL7, which created a GIS road file (Road91) that could be used for road density and distance to road analyses.

Road density maps:

Using the original rasterized road map Road91, 2 individual road maps were created by combining (reclassifying) the 6 different road classes using different criteria. Map 1R was of all roads except those that were revegetated. Map 2R was of permanently and seasonally open roads. The reclassified maps were then used to create 2 density maps (map 1R to map 1, map 2R to map 2) using the EPPL7 program MOVING window. A 53X53 (1 mi^2) moving window would move one cell at a time and count the number of road cells within one mi^2 of that center cell and then assign the count to that cell. By using a scaling option of 13 we were able to produce cell values that were in .25 mi increments. The classes were then combined into 10 classes at .5 mi increments (Table 2).

The road density maps were built using roads on an area larger than the study area so that when we cut the road density maps to fit the study area, roads outside the area still had an effect on the road density within the study area. Once the density maps were fit to the study area then grizzly bear locations were placed on the map and frequency counts were obtained. Availability/use analysis followed Byers et al. (1984). Statistical significance was accepted at p<=.05.

Table 2. Descriptions for the 10 classes of road density.

CLASS	DESCRIPTION
RDEN0	>.5 mi from road and density = 0
RDEN1	<.5 mi from road and density = .01 to .5 mi/mi^2
RDEN2	<.5 mi from road and density= .5 to 1 mi/mi^2
RDEN3	<.5 mi from road and density= 1 to 1.5 mi/mi^2
RDEN4	<.5 mi from road and density = 1.5 to 2 mi/mi^2
RDEN5	<.5 mi from road and density = 2 to 2.5 mi/mi^2
RDEN6	<.5 mi from road and density = 2.5 to 3 mi/mi^2
RDEN7	<.5 mi from road and density = 3 to 3.5 mi/mi^2
RDEN8	<.5 mi from road and density = 3.5 to 4 mi/mi^2
RDEN9	<.5 mi from road and density = 4+ mi/mi^2

Road91 was also cut to fit the study area creating map Road91A. Counts of cells of the different road classes on Road91A road were then used to calculate road mileage for the different classes. This resulted in average road densities for the entire study area.

Digital elevation map:

A digital elevation map of 40 ft. contours was rasterized to 30 m cell size for 70% of the study area. The entire elevation map

for the entire study area was not available. The elevation file was reclassed into 9 elevation zones based on 500 ft. intervals.

Satellite Imagery

A 1981 MSS LANDSAT satellite image was classified by the Flathead National Forest. A portion of that classified image covering Wheeler Creek was extracted, printed at a scale of 1:24,000 and compared to color aerial photographs and taken to the field in an attempt to determine its use for mapping grizzly bear habitat.

In November of 1990, a portion of an August 1988 Thematic Mapper (TM) satellite image quarter scene was windowed out, using ERDAS (1991), to cover the study area. The TM scene was at 30 meters resolution and it was believed that for mapping grizzly bear habitat that this finer resolution was desirable over the 50 meter MSS map. Preprocessing of the raw data involved histogram adjustments to account for atmospheric scattering (Jensen 1988). The adjusted image was then transformed into 3 features, using coefficients for the creation of Tasseled Cap Features, (Crist and Cicone 1984), that represent brightness, greenness, and wetness. The transformed data was sampled into 30 clusters using ISODATA (ERDAS) to create a signature file. Using MAXCLAS (ERDAS) the transformed image was converted into a 30 class GIS file using the minimum distance to the mean. The GIS file was rectified to ±.5 pixel using topographic maps and UTM coordinates. The same procedure was subsequently used to develop a 30 class GIS file for the entire quarter scene. Point or buffered grizzly bear locations,

roads, trails, and other human activities were placed on the different GIS files resulting in frequency counts that were used for analyses.

PRELIMINARY RESULTS

Captures and telemetry

Thirty-five individual grizzly bears have been captured and radio-collared since the fall of 1987 (Appendix A). Twenty-seven of those bears were relocated by fixed-wing aircraft at least ten different times.

A total of 2,724 grizzly bear locations have been recorded to date for the entire South Fork Grizzly Bear Project 2,002 (73%) were class 1, 101 (4%) class 2, 197 (7%) class 3, 118 (4%) class 4, 189 (7%) class 5, 92 (3%) class 6, 6 (.2%) class 7, and 15 (1%) class 8.

Radio locations accounted for 2,508 of the locations (2,138) (85%) aerial, 365 (15%) ground). Ninety-seven percent of the radio locations were on National Forest lands. The majority (60%) were on the Spotted Bear Ranger District, 27% on Hungry Horse, and 9% on Swan Lake. Less than 4% were on State Forest and private lands combined.

For this report only the 2,002 class 1 locations were used. Sixteen (.79%) were from 1987, 233 (11.6%) from 1988, 356 (17.3%) from 1989, 663 (33.1%) from 1990, and 734 (36.6%) from 1991. The increased number of locations for 1990 and 1991 were due to

increasing the number of flights from one to two per week.

Grizzly bear locations were categorized into five preliminary seasons based upon food habits, plot information, and visual observations. Some of these seasons vary by individual bear (such as denning) or by year (foraging on _Vaccinium_ spp.). Additional seasons may be added or dates changed as more information is collected. The five seasons were:

1. Denning - the bear has entered the den for the winter and has not yet emerged in the spring. This date can vary by bear and year. Dates: enter 10/22-12/10, all in 12/11-3/11, emerge 3/12-4/22.

2. Early spring - Evidence that the bear has emerged from the den and is still at the den site or may have moved away, but not all of the bears have moved away from the den. Dates: 3/12-5/6.

3. Spring - all bears are away from the den site and have begun normal activity. Foraging primarily on grasses, forbs, and mammals. Breeding occurs during this season. Dates: 5/7-7/15.

4. Summer - bears have switched to a diet primarily of _Vaccinium_ spp. Dates: 7/16-9/17.

5. Autumn - _Vaccinium_ spp. not the primary food source. Bears foraging on persistent berries (ie. Sorbus spp.), roots, gut piles from hunter kills, and preparing dens. Dates: 9/18-12/11.

Seventy-six (3.8%) of the locations were denning, 193 (9.6%) early spring, 618 (30.7%) spring, 789 (39.4%) summer, and 326 (16.4%) autumn.

Monthly locations ranged from March into December with the greatest number of locations from July (Figure 2).
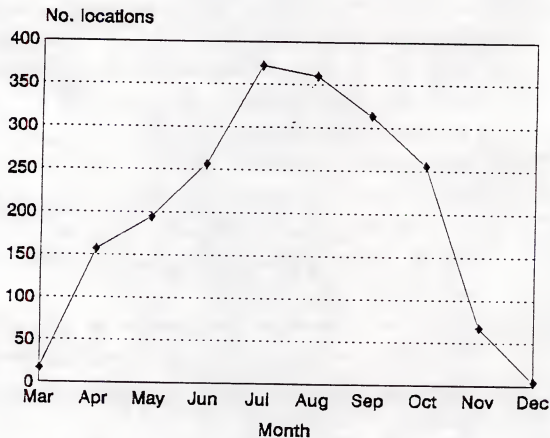
No. locations

Figure 2. Total number of class 1 grizzly bear locations by month (1987-1991).

Grizzly bear locations were also categorized by week. Weekly divisions were fine enough to note changes in grizzly bear food habits, breeding, movements, and denning. It was these weekly changes that actually set the framework for the seasonal categories. Plotting locations by week also showed where aerial

sampling was lacking (ie. week 17), or where only one flight during a week may be necessary to even out the sample (ie. week 28) (Figure 3).
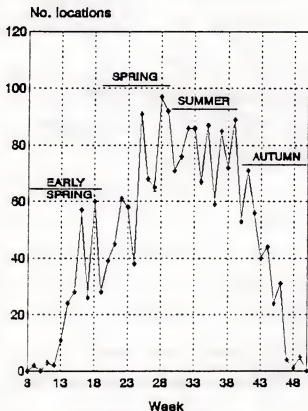
No. locations

Week 8: Feb 19-25; Week 50: Dec 10-16

Figure 3. Total number of class 1 grizzly bear locations by week and season (1987-1991).

Aerial locations were obviously biased toward daytime locations. Seventy-five percent of the locations were obtained between 0500 and 1200 Mountain Standard Time (MST). The earliest location was 0515 MST and the latest was 2040 MST. During 1991, an extra effort was made to increase the late evening aerial sample. Weather conditions usually make afternoon flights impossible, therefore the mid-afternoon sample was not targeted for an

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increase. Accurate aerial locations during darkness in mountainous terrain were not obtainable.

Of the 2,002 locations, 471 (23.5%) were visual observations of the bears from the plane. Visual observations ranged from a low of 6% in 1987 to 31% in 1991. May had the highest observation rate (31%) followed by September (30%). Females with yearlings were observed most often (32%), and subadult females the least (18%). Observations of individual grizzly bears varied from 45% for bear #36 to 0% for bear #98.

Road density information

The study area had a total of 758 miles of roads which were not revegetated. Average road density for the study area was 1.34 mi/mi^2. Permanently open roads included 403 miles (53%), for an average permanently open road density of .71 mi/mi^2. There were 355 miles of restricted roads (permanent or seasonal closures). Of that total 109 (31%) miles were seasonally restricted and 246 (69%) miles were permanent closures. There were 101 miles of revegetated roads that were omitted from further analysis.

When class 1 grizzly locations (n=1667) were placed on road density map 1 there was a significant difference in use of the 10 road density classes (X^2=238, df=9, p=.000). Areas with road densities of less than 1 mi/mi^2 received significantly greater use than expected. Areas with road densities of 1.0-2.0 mi/mi^2 received use as expected and when road densities exceeded 2 mi/mi^2 grizzly bear use was significantly less than expected.

The same grizzly bear data on road density map 2, also resulted in significant differences in use of the 10 road density classes (X^2=240, df=9, p=.000). Grizzly bears used only the area with zero road density significantly greater than expected. Areas with road densities of .01-1.0 mi/mi^2 were used as expected and when road densities exceeded 1.0 mi/mi^2 use was significantly less than expected.

Road density use by sex and reproductive status:

Differences in use of road density classes were observed for males (n=520) and females (n=1164). Both sexes continued to show significantly greater use of the road density class 0 mi/mi^2 on map 1. Also for map 1 males used the remaining road density classes as expected except for the 2.5 to 4.0 mi/mi^2 classes where use was significantly less than expected. Females on map 1 used areas with road densities less than 1 mi/mi^2 significantly greater than expected. Road density areas of 1.0-2.0 mi/mi^2 were used as expected whereas use was significantly less than expected when densities exceeded 2.0 mi/mi^2.

For map 2 use patterns were similar to map 1. Both sexes used the zero road density class significantly greater than expected. Males used the remaining classes as expected except for the 2.5-3.0 and 4+ mi/mi^2 classes where use was significantly less than expected. Females used the .01-1.0 mi/mi^2 classes as expected and when road densities exceeded 1.0 mi/mi^2 use was significantly less than expected.

By further stratifying the data by sex and reproductive status we began to detect differences especially with the female segment of the population. Locations of females with cubs on map 2 showed use greater than expected for road density class zero and use as expected for density classes less than 1 mi/mi^2. When road densities exceeded 1 mi/mi^2 use was significantly less than expected. Females with yearlings on map 2 showed no difference in use of the road classes (X^2=7.7, df=97, p=.57). Use was as expected in all but the 4+ mi/mi^2 class where use was less than expected. Mattson (1986), felt that females with cubs of the year selected the most secure habitat in which to raise cubs. Since we ascertained that females with cubs were using the most secure habitats in terms of road densities, we looked more closely at that segment of the population to see if we could further define areas important to females with cubs.

Effects of elevation on road density and grizzly bear selection:

A preliminary look at the study area revealed that the highest road densities were in the lower elevations. From the elevation map we observed that a majority of the roads and the highest road densities occurred below 5,000 feet. When we overlayed the female/cub locations on the elevation map we found significant differences in elevational use among the 9 elevation zones (X^2=128, df=8, p=.000). Use was significantly greater than expected from 5,500 ft to 7,000 ft and significantly less than expected below 4,500 ft. However from this information it was difficult to

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determine if females with cubs were avoiding areas with high road densities or use was strictly elevational. To assess this question we looked at the proportion of each road density class within each of the elevational zones to determine if a relationship existed among the proportion of female and cub locations within each elevational zone.

We ascertained that the proportion of females with cubs within each elevational zone was highly correlated to the proportion of unroaded habitats (road density=0) within each elevational zone ($r=.98$). When the same procedure was applied to adult males, the correlation with unroaded habitats was less ($r=.59$). In fact adult male use was more highly correlated to the proportion of total habitat available within each elevational zone ($r=.90$). Figures 4 and 5 display the relationship between the proportion of unroaded habitat, total area, and females/cubs and adult males, respectively, by elevational zone. It appears that females with cubs are selecting those elevations above 5,000 feet due in part to the fact that that is where the largest areas of unroaded habitat are.

Road closures appeared to help in providing necessary security areas for females with cubs. When road densities were calculated using map 1, 36% of the study area had a road density of zero. Forty-eight percent of map 2 had a road density of zero. By increasing the amount of "unroaded" habitat by 12% the number of locations of females with cubs increases 23%. Perhaps a better way to illustrate the effects of calculating road densities is to look
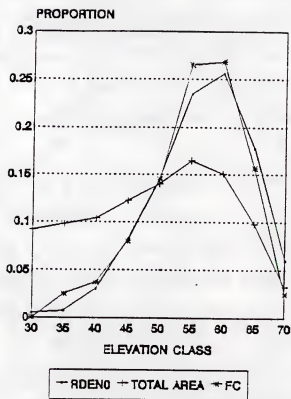
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Figure 4. Proportion of unroaded habitat, total habitat, and locations of female grizzly bears with cubs by elevation zone.
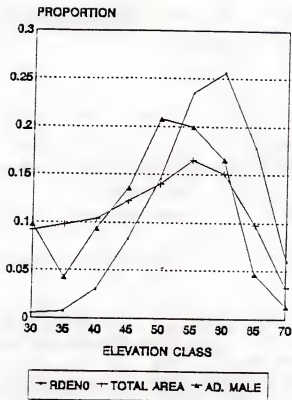
Figure 5. Proportion of unroaded habitat, total habitat, and locations of adult male grizzly bears by elevational zone.

at use by females with cubs versus availability on the different road density maps (Table 3).

Table 3. Road density classes and respective use/availability analysis for female grizzly bears with cubs on maps 1 and 2.

DENSITY CLASS	ALL ROADS (Map 1)	OPEN ROADS (Map 2)
0 = 0 mi/mi^2	+	+
1 =. 01-.5 mi/mi^2	=	=
2 = .5-1.0 mi/mi^2	=	=
3 = 1.0-1.5 mi/mi^2	=	-
4 = 1.5-2.0 mi/mi^2	=	-
5 = 2.0-2.5 mi/mi^2	=	-
6 = 2.5-3.0 mi/mi^2	-	-
7 = 3.0-3.5 mi/mi^2	-	-
8 = 3.5-4.0 mi/mi^2	-	-
9 = 4.0+ mi/mi^2	-	-

+ use greater than expected ($p<.05$)

= use as expected

- use less than expected ($p<.05$)

Road cameras

The cameras were deployed 2045 days and were operational 1706 of those days, for an operational efficiency of 83%. A total of 6,553 photographs were taken resulting in 25 (.38%) photographs of grizzly bears. On 3 of those occasions the grizzly bear was photographed more than once. Therefore, 22 separate grizzly bear events were recorded resulting in 1 grizzly photo in 77.5 camera days. Of those 22 events, 9 (41%) were during daylight hours, and 59% at night. Twelve of the photographs were of 3 marked grizzly bears (M#22, FC#45, m#71). Four photographs were identified as M#146 (lost collar and tags but unique markings). The remaining 6 photographs were of unidentified grizzly bears. One photograph of a female and cub (#45) was obtained in mid October. All of the remaining identifiable bears were males. Eight photographs of grizzly bears were during June, with 6 in August. May and July had the lowest number at 1 each. June had the highest photographic rate at .029 grizzly bears per camera day. July had the lowest at .002 grizzly bears per camera day. Sixteen (73%) of the grizzly bear photographs were on open roads, 5 (23%) on permanently closed roads, and 1 (4%) on seasonally closed roads.

Vehicles were photographed 2056 times resulting in 1219 vehicle trips (55% general public, 38% research, 7% Forest Service). Approximately 99% of the vehicle traffic occurred during daylight. July had the most traffic recorded but September had the highest ratio of .88 vehicle trips per camera day. June had the lowest at .29 vehicle trips per camera day. There was a

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correlation between camera days and vehicle trips recorded (r^2=.78), but no correlation between camera days and grizzly bears recorded (r^2=.04). There was no correlation between vehicle trips and grizzly bears photographed (r^2=.05), but there was a negative correlation (r=-.76) between vehicle trips per camera day and grizzly bears photographed per camera day.

We used 1991 as a test year for placing cameras on roads to see if the information gathered was worth the expense and time. From these results we saw at least 4 useful applications of the road cameras: 1) The cameras gave physical documentation of when grizzly bears were in the roaded areas, 2) the cameras can help calibrate the traffic counters that were on the roads, 3) provided information on the types of users on the forest roads (ie. general public or forest service), and 4) they provided further documentation of unmarked bears in the study area.

Validation of satellite habitat map

A total of 287 Ecodata plots were conducted within the 30 spectral classes in conjunction with the Flathead National Forest. The plot information was gathered to help in ground truthing the satellite image. Preliminary analysis of the plot data revealed that some classes had very little variation in terms of vegetative cover. Other classes showed some confusion between shrubfields and dense coniferous forest on different aspects. In order to refine the map, digital elevation models were used to create maps of elevation, slope, and aspect. When these 3 attributes are combined

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with the spectral map preliminary indications are that we will be able to produce a realistic vegetation map for the study area. We have also used images incorporating elevation, slope, aspect, sun angle, and sun direction into maps depicting relative solar radiation. By combining the solar radiation map with the spectral map we have seen a great improvement in reducing confusion within spectral classes.

We will need some additional plot information for some spectral classes at various elevations, slopes, and aspects to refine the definitions for the classification.

Although the vegetation map is not yet completed it is interesting to note that by placing grizzly bear locations on the spectral class map we are still seeing strong use of just a few of the classes.

Combined effects of human activities on the grizzly bear population

The data contained in this annual report are preliminary. Results are subject to change as we gather and analyze more information on habitat use, effects of roads and logging, and population parameters. However, we believe that the data presented herein are of sufficient quality and quantity that several qualitative observations are warranted.

It is our belief that the observed responses of grizzly bears to human activity (as demonstrated by forest roads) in the Swan Mountains could be extrapolated to other multiple-use areas in the NCDE. Similarities in climate, habitat features, and the

physiographic location of roads support this contention. Our data were derived from an area with a combined average open and seasonally open road density of .91 mi/mi^2 (in the 1980's through 1991) and a 40 year history of logging and improved human access. We believe that our analyses of the relationships between roads and grizzly bears represents a composite response to all forms of human activities associated with road access be it hunting, berry picking, hiking, hydroelectric development, road maintenance, or timber harvest. The relationships we have observed are no doubt the results of long-term behavior modification of those grizzly bears that survived through the 1970's and 1980's and ultimately became a part of our instrumented sample of bears. In other words, the bear population had already made the adjustments to human intrusion prior to our research and we simply documented the more obvious manifestations of those adjustments.

Within the NCDE, humans have made the decision on where grizzly bears will be tolerated and where they will not. Almost without exception, tolerance is greatest in the more remote portions of the Ecosystem. Opportunities for grizzly bears to expand their range into the broad valleys (e.g. Flathead, Tobacco, Mission) have been generally lost. By default then, we are attempting to promote grizzly bear survival in the most mountainous areas. The data we have presented shows clearly that grizzly bears are capable of living in habitats administered for multiple-use values at present levels (1991) of human activity. However, our data also show that females and females/cub choose the most secure

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habitat patches within these multiple use lands; patches with road densities of 0 mi/mi^2. Habitat patch size, quality, and location appear to be very important to this segment of the population. The term "security" is probably relevant to grizzly bears, especially females, on several levels; for example security from other bears or security from human activities.

There are some fundamental differences in grizzly bear habitat use, survival rates, and demographics within the NCDE. These differences no doubt reflect differences in mortality patterns, bear management schemes, and basic habitat productivity. McLellan (1988) and Aune and Kasworm (1989) have studied grizzly bear populations in highly productive floodplain and mountain/prairie habitats respectively. Both populations have expanded in recent years and grizzly bears in both areas take advantage of wild ungulates or livestock food sources which Swan Mountain grizzlies have in only limited supply. In both areas, females spatially coexisted with males in the better low-elevation habitats. We do not see this pattern in the Swan Mountains. In the case of the East Front area, it is interesting that females are colonizing Great Plains habitat. The point here is that such new colonization is occurring because a.) the low-elevation habitat areas were good but unfilled because of past management, b.) the areas have adequate security from humans or other bears, c.) more females are surviving and looking for areas to live, and d.) these area constitute quality habitat niches to utilize.

In the case of the Swan Mountain data, it appears that females

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now live and reproduce in the undisturbed and unroaded high-elevation patches. Although these females are not territorial in the classic sense, spacial and temporal overlap among females is minimal. In terms of survival, there are ramifications of living in these relatively harsh environments. 1) Human mortality on females will be minimized because of access and terrain. 2.) Natural mortality will be relatively high because it is a difficult place to live. For example, female survival rates (adult and subadult) in the Swan Mountain study area are lower than either the East Front or the North Fork, and differences appear to be related to natural mortality.

Given this scenario, management opportunities to promote population growth will be reduced because of limited "usable" space, especially for females. We have not yet assessed changes in grizzly bear distribution relative to road closure programs. However, it is our belief that grizzly bears would respond slowly to such closures, and that it would take several bear generations for the population to "regain" lost habitat. To promote grizzly bear population growth beyond 1991 levels in managed habitats will require mangers to 1:) refine methods for calculating road densities which do not rely on average road densities over large blocks of habitat, we suggest using methods similar to those used in this paper, 2:) develop permanent road closure policies of < 1 mi of open road/mi^2, 3:) preserve all, but especially mid to high-elevation undisturbed (unroaded/unlogged) habitats to maximize female "security areas."

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APPENDIX A

Appendix A. Number and current status of all grizzly bears captured within the South Fork Study Area as of Dec. 1991.

BEAR	SEX	AGE AT CAPTURE	DATE FIRST CAPTURED	CURRENT STATUS
1	F	11.5	09/04/87	DEAD BEAR
3	F	1.5	09/11/87	DROP COLLAR
5	F	7.5	09/16/87	ACTIVE
12	F	3.5	05/29/89	DEAD BEAR
13	M	7.5	06/01/89	DEAD BEAR
14	F	11.5	06/01/89	ACTIVE
18	F	2.5	06/20/89	ACTIVE
22	M	3.5	06/18/89	ACTIVE
25	M	4.5	06/09/90	DROP COLLAR
32	F	1.5	05/13/91	DROP COLLAR
33	M	1.5	05/21/91	ACTIVE
34	F	1.5	05/29/91	ACTIVE
35	F	1.5	05/30/91	ACTIVE
36	M	4.5	05/30/91	ACTIVE